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INVESTIGATION OF TRITIUM CONTAMINATION ON TITANIUM ION-GETTER PUMPS

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INVESTIGATION OF TRITIUM CONTAMINATION ON TITANIUM ION-GETTER PUMPS

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ABSTRACT

The titanium ion-getter pumps in neutron generators are exposed to contamination from the tritium gas released from the targets.

Examinations of an ion-getter pump removed from a neutron generator after two years of operation are reported. The pattern of tritium contamination in the different structural elements established by activity measurement and autoradiography are discussed and procedures for safe handling and regeneration of the contaminated pumps are suggested.

РЕЗЮМЕ

В сорбционно-ионных насосах, применяемых в нейтронных генераторах, часть трития, выделенного из использованных мишеней, поглощается. В статье описывается измерение деталей сорбционно-ионного насоса, разработанного после двухлетней работы, а также результаты авторадиографического испытания и рассматривается метод безопасного разбора и реконструкции насоса.

KIVONAT

A neutrongenerátoroknál használt ion-getter szivatytyukban az üzemelés során felhasznált targetekből felszabaduló tricium egy része elnyelődik.

Ismertetjük a kétéves használat után leszerelt iongetter szivattyu alkatrészeinek aktivitásmérését és az autoradiográfiás vizsgálat eredményét, valamint a szivattyu biztonságos szétszerelésének és regenerálásának módját.

INTRODUCTION

Ion-getter pumps are extensively applied to produce the high vacuum required for neutron generators operated in activation analytical and nuclear physics laboratories. Neutrons with energies around 14 MeV are generated by $^{3}T/d,n/^{4}He$ reaction in Ti-T or Zn-T targets bombarded with deuterium ions accelerated to 120-200 keV. The tritium activity of the targets varies from 10 Ci to 30 Ci and their useful life expectation is between 10 and 15 hours. Obviously, considerable amounts of tritium are released in routinely operated neutron generators and part of this activity is absorbed by the ion-getter pump of the vacuum system.

Thus, when it comes to servicing and regeneration of ion-getter pumps, in order to devise suitable precautions for preventing contamination of the laboratory and exposure of personnel to ingestion hazards, it becomes necessary to know the extent of tritium contamination of the titanium cathode plates and the interior walls of the pump, as well as the state of the cathode surfaces /pulverization, desorption etc./.

EXPERIMENTAL

After two years of operation, the ion-getter pump was dismounted from the NA-2 type neutron generator installed in the Analytical Laboratory of the Central Research Institute for Physics, Budapest. The total activity of the titanium tritide targets utilized in the generator over the 2-year period amounted to 167 Ci.

The pump was stripped down in a hot laboratory according to the prescribed safety measures. One set of the electrode cells was removed from the pump and dismantled in a hood. The titanium cathode surfaces showed some discolouration and a thinning of the plates at the so-called hot spots, in the centre of the cathodes, facing the anode cells. The anode surfaces were coated with an easily pulverized, peeling layer. This coating was found to be produced mainly by the titanium sputtered from the cathode. A block diagram of the ion-getter pump is shown in Fig. 1. The disassembled electrode system can be seen in Fig. 2.

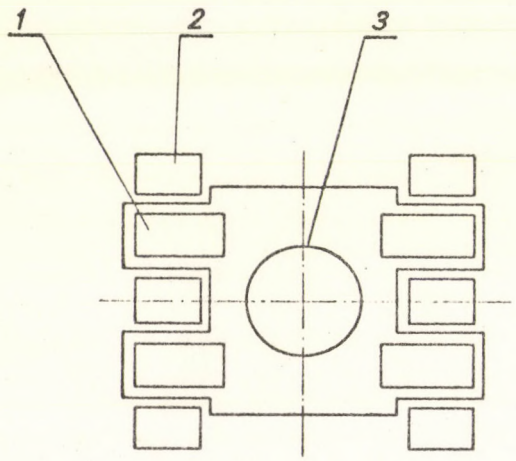

Fig. 1

Block diagram of the ion-getter pump.

1. electrode system;
2. magnet;
3. baffle

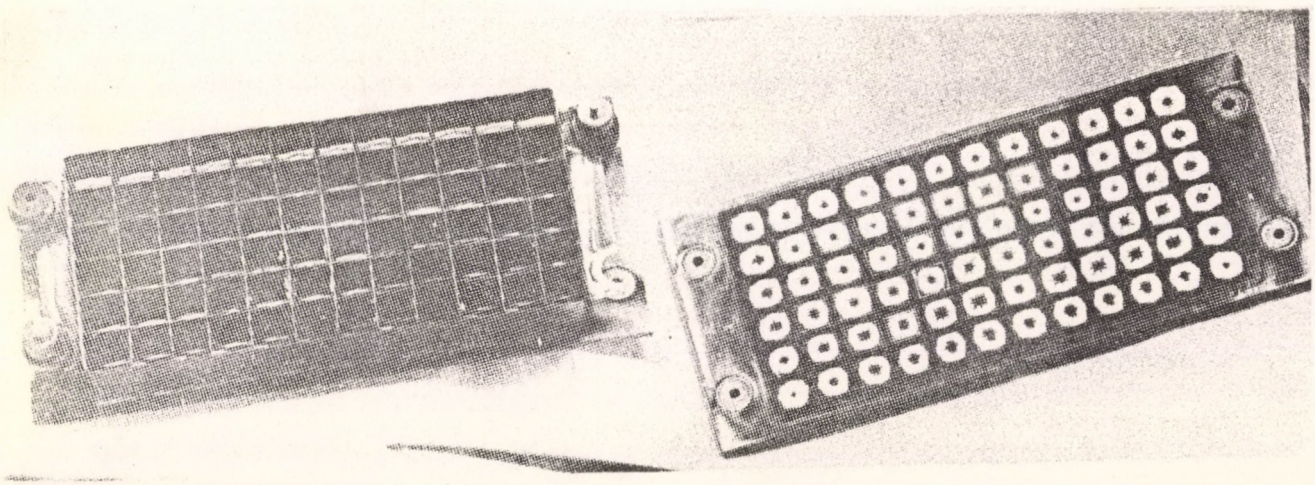

Fig. 2

Disassembled electrode system of the ion-getter pump

To evaluate the amount of tritium absorbed by the pump, wipe samples were taken from the interior walls and the cathode surfaces and scrapings from the coating on the anode surfaces. /The sampled area was supposed to be 100 cm^2 in each test but, because the surfaces were non-planar, it could not be determined accurately./ All samples were then combusted and their activity measured with a liquid scintillation spectrometer [1]. The results of the measurements are listed in Table I.

Table I. *Surface contamination of pump components*

Area sampled	Activity (μCi/sample)	Type of test
interior wall	1.74	wipe test
bottom	7.26	"
baffle	160.2	"
cathode surface facing the anode	4.6	"
rear surface of cathode	$2.6 \cdot 10^{-2}$	
anode surface	5.5 μCi/mg	scrape test

The tritium distribution over the cathode surface was established by autoradiography [2]. The autoradiogram of the entire cathode surface and the density distribution over three adjecent cells can be seen in Fig. 3 and Fig. 4 respectively.

The autoradiogram shows a fairly even distribution of activity over the areas of the cathode surface facing the anode cells, while the activity on areas opposed to the interstices between the anode cells is less by order of magnitude. This finding is consistent with the observed hydrogen absorption by titanium cathodes measured with inactive technique [3].

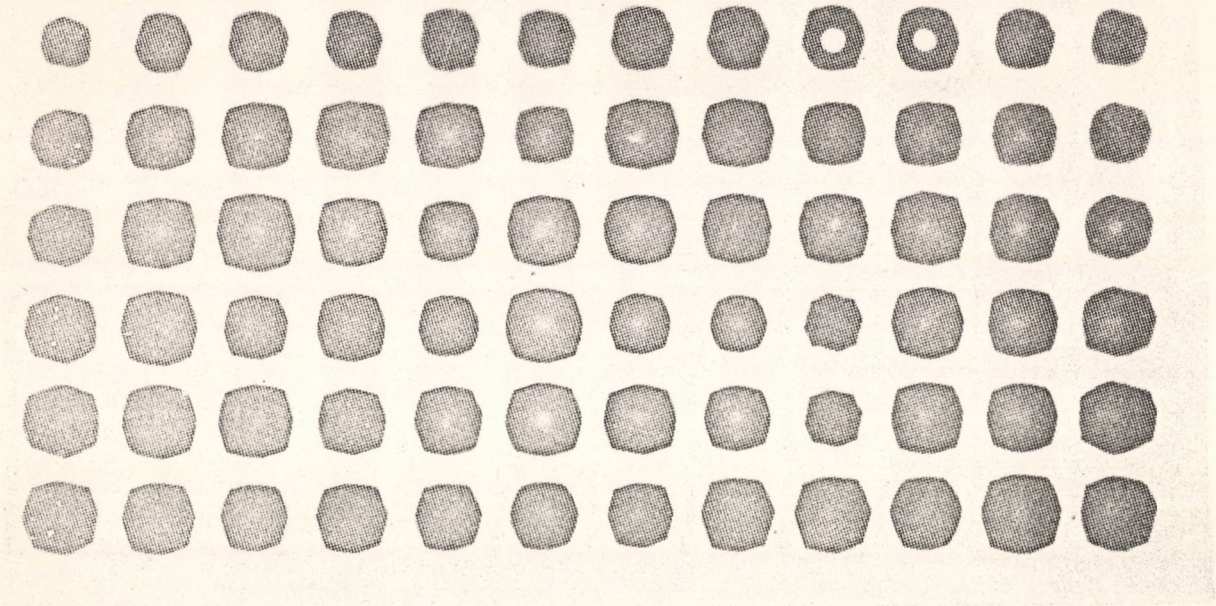

Fig. 3

Autoradiogram of the entire cathode surface

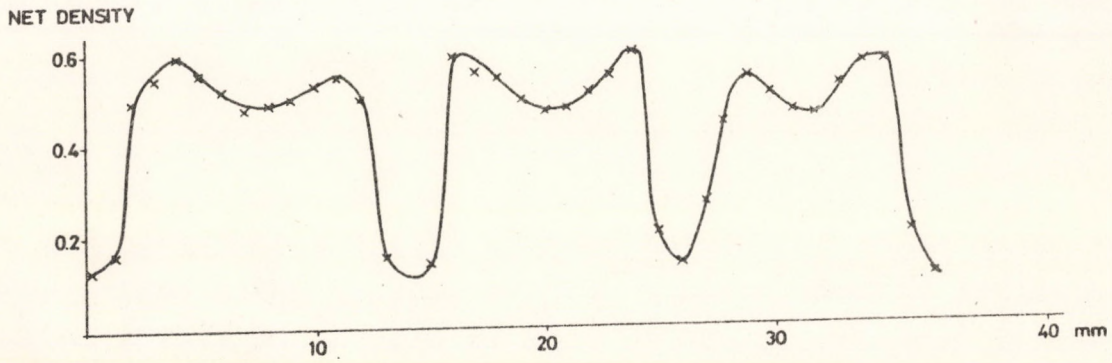

Fig. 4

Density distribution of the autoradiogram of three adjecent cells

The tritium distribution along the vertical axis of the titanium cathode was determined from samples taken at different depths from holes drilled into one of the hot spots and into a point of the cathode surface in an interstitial position. The results of the activity measurements are presented by the diagram in Fig. 4.

If the tritium absorption calculated from the two curves in Fig. 5 is taken to be the average absorption of tritium by titanium, then the total activity absorbed by the 1400 g of titanium contained in the pump is less than 8 Ci, i.e. about 5% of the total target activity introduced into the generator.

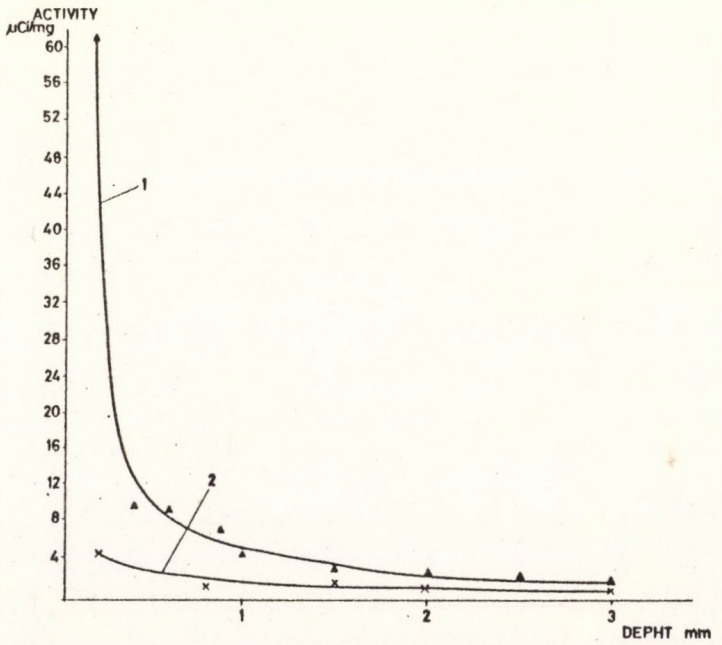

Fig. 5

Activity distribution of the cathode; curve 1 hot spot; curve 2 interstitial position

The release of tritium activity from the titanium cuttings produced by drilling was measured in both distilled water and 1 N hydrochloric acid. No appreciable change was observed in the activity of the cuttings over 24 hours, while

the activity of the liquids was found to be less by four orders of magnitude than that of the titanium.

CONCLUSION

It can be concluded from these observations that only a small fraction of the tritium activity contained in the NA-2 generator targets is absorbed by the ion-getter pump. Part of the contaminant activity is strongly bound by the titanium cathode in the form of metallic tritide, irremovable even by hydrochloric acid. The activity of the coating on the interior walls and the anode cells is less than 50 mCi/g.

For the regeneration of the ion-getter pumps a closed washing system with filtered and monitored discharge of water should be used. It is advisable to remove the electrodes only from an already thoroughly washed pump. The electrodes have then to be disposed of as contaminated material and replaced by new cells. Before remounting the pump into the generator, it should be carefully checked that the tritium contamination has been sufficiently removed from all exposed surfaces.

ACKNOWLEDGEMENT

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REFERENCES

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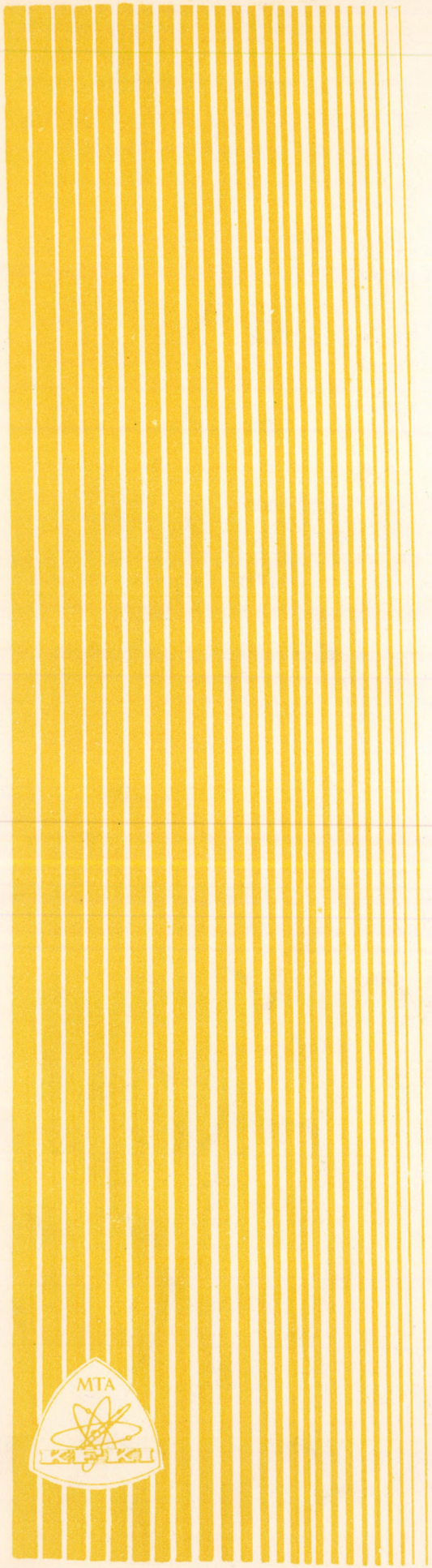

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